299-W18-162 (A7644)
Log Data Report

Borehole Information:

Borehole:	299-W18-162 (A7644)			**Site:**	216-Z-12 Crib
Coordinates (WA St Plane)		**GWL[1] (ft):**	None	**GWL Date:**	02/14/06
North (m)	**East (m)**	**Drill Date**	**TOC Elevation**	**Total Depth (ft)**	**Type**
135466.312	566363.837	09/76	685.17 ft	30	Cable

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Welded steel	1.1	7 1/4	6 1/2	3/8	1.1	30
Welded steel	0.75	12 3/4	12	3/8	0.75	7.3

Borehole Notes:

Casing diameter and casing stickup measurements were acquired by the logging engineer using a caliper and steel tape. Measurements were rounded to the nearest 1/16 in.

All logging measurements are referenced to the top of casing.

Logging Equipment Information:

Logging System:	Gamma 4A		**Type:** **Serial No.:**	SGLS (70%) 34TP20893A
Effective Calibration Date:	05/11/05	**Calibration Reference:**	DOE-EM/GJ891-2005	
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0	

Logging System:	Gamma 4I		**Type:** **Serial No.:**	Passive Neutron U1754
Effective Calibration Date:	None	**Calibration Reference:**	None	
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0	

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2 Repeat	3 Repeat	4 Repeat
Date	03/07/06	03/07/06	03/08/06	03/08/06
Logging Engineer	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	25.5	24.5	24.5	21.5
Finish Depth (ft)	1.5	18.5	18.5	19.0
Count Time (sec)	200	800	200	200
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	0.5
ft/min	N/A[2]	N/A	N/A	N/A
Pre-Verification	DA091CAB	DA091CAB	DA101CAB	DA101CAB
Start File	DA091000	DA091025	DA101000	DA101007
Finish File	DA091024	DA091031	DA101006	DA101012
Post-Verification	DA091CAA	DA091CAA	DA101CAA	DA101CAA
Depth Return Error (in.)	0	0	0	0
Comments	No fine-gain adjustment	No fine-gain adjustment	PVC sleeve test No centralizer	PVC sleeve test No centralizer

Passive Neutron Logging System (PNLS) Log Run Information:

Log Run	3	4 Repeat		
Date	03/08/06	03/08/06		
Logging Engineer	Spatz	Spatz		
Start Depth (ft)	25.5	24.5		
Finish Depth (ft)	1.5	18.5		
Count Time (sec)	60	60		
Live/Real	R	R		
Shield (Y/N)	N	N		
MSA interval (ft)	1.0	1.0		
ft/min	N/A	N/A		
Pre-Verification	DI332CAB	DI332CAB		
Start File	DI332000	DI332025		
Finish File	DI332024	DI332031		
Post-Verification	DI332CAA	DI332CAA		
Depth Return Error (in.)	0	0		
Comments	None	None		

Logging Operation Notes:

Pre- and post-survey verification measurements for the SGLS were acquired using the Amersham KUT (K-40, U-238, and TH-232) verifier with serial number 115. A centralizer was installed on the sondes except for a PVC sleeve test (log runs 3 and 4).

The interval from 18.5 to 24.5 ft was logged with the SGLS at 800 second counting times to acquire additional detail and lower the MDLs for radionuclides.

Passive neutron logging was also performed in the borehole. This logging method has been shown to be effective in qualitatively detecting zones of alpha-emitting contaminants from secondary neutron flux generated by the (α, n) reaction and may indicate the presence of transuranic radionuclides.

A PVC sleeve was placed over the sonde to determine if the neutron flux would cause neutron capture gamma rays from the chlorine in the PVC.

This borehole contained internal alpha contamination as determined from wipes of the cable and sonde on March 8.

Analysis Notes:

Analyst:	Henwood	Date:	02/27/08	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre- and post-run verification spectra were collected at the beginning and end of the day's logging. All of the verification spectra were within the acceptance criteria although the post verification spectra for March 8 indicated a loss in efficiency at 2615 keV energy peak of approximately 10 percent during the day. Examination of data indicates that the detectors functioned normally during logging, and the data are accepted.

An AmBe neutron source was used for verification measurements with the passive neutron logging system. Currently there are no verification criteria established for this system. The counts obtained from the pre- and post-verifications were within 1 percent.

Log spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file: G4AMay05.xls for the SGLS). A casing correction for 0.75-in. thick casing was applied to the data from 0 to 7.3 ft and 0.375-in. for the remainder of the borehole.

Results and Interpretations:

Am-241 is detected from 19 to 21.5 ft. The maximum concentration is measured at approximately 3,600,000 pCi/g at 20.5 ft. Gamma rays at approximately 662, 722, and 208 keV were detected that represent Am-241. Cs-137 emits a 661.66 gamma ray that cannot be distinguished from the 662.40 gamma ray emitted from Am-241. The energy peak at 722.01 keV is used to establish the presence of Am-241 rather than Cs-137. In this borehole the 722.01 keV energy peak is used to determine the Am-241 concentration. When comparing the assays for Am-241 using the 662 and 722 keV energy peaks, there appears to be residual counts in the 662 keV energy peak that may be attributed to Cs-137. On the basis of the 722.01 keV assay, counts were subtracted from the 662.40 keV energy peak to yield an approximate concentration for Cs-137.

Using this approach, Cs-137 is detected from 19 to 21.5 ft. The maximum concentration of 1570 pCi/g is measured at approximately 19 ft, just above the depth of 20.5 ft where the maximum concentrations of other radionuclides were detected. However, it is presumed that few, if any, fission products would reside in a waste stream originating from PFP. It is possible that sufficient neutron activity exists that could cause limited fissioning of the Pu. Other possibilities for the existence of 662 keV gamma rays are being investigated.

The Am-241 concentrations derived from the 208.01 keV gamma line are significantly over estimated. A 208.000 keV gamma line that results from the decay of U-237 (daughter of Pu-241), interferes with the 208.01 keV gamma line caused by the decay of Am-241. For purposes of this report, it is assumed that all of the counts in the 208 keV energy peak that cannot be attributed to Am-241, reflect decay of U-237. Assuming the waste stream is aged (e.g., 40 years or more), U-237 has grown into equilibrium with its parent Pu-241. Equilibrium is a condition where the rate of production of a nuclide by radioactive decay equals the rate of decay of that nuclide. In other words, in an equilibrium condition the activity of a daughter product will equal the activity of the parent. After subtracting the influence of Am-241 from the 208 keV energy peak, it is estimated Pu-241 exists at 20.5 to 21.5 ft at a maximum concentration of approximately 16,000,000 pCi/g; the maximum concentration is at 20.5 ft in depth.

Pu-239 was detected from 19.5 to 22 ft. The maximum concentration was measured at approximately 13,000,000 pCi/g at 20.5 ft. Primary energy peaks associated with Pu-239 were detected at approximately 345, 375, and 414 keV. Interferences from the 375.45 and 376.65 keV energy lines and the 415.76 and 415.88 keV gamma energy lines originating from the decay of Pa-233 and Am-241, respectively, are probable and would result in a slight over estimation of the Pu-239 concentration. However, assays compared with the 345.01 keV energy peak (which has no obvious interferences) are consistent. Therefore, it is concluded the interferences are minor. The assay using the 413.71 keV energy peak is the most reasonable and is used to determine concentrations of Pu-239. The yields of the 413.71 and 375.05 keV gamma rays are similar (0.0015 and 0.0016 percent, respectively) and an order of magnitude greater than the 345.01 keV yield (0.006 percent). The 375.05 keV gamma line has more potential interferences than the 413.71 keV gamma line.

Weapons grade plutonium is generally defined as approximately 6 % by weight of Pu-240. The table below relates a hypothetical weapons grade Pu mix of the dominant isotopes by weight to activity.

Isotope (Weapons grade)	Pu-239	Pu-240	Pu-241
Half life (years)	24,110	6,563	14.35
Weight (percent)	93.8	5.8	0.13
Activity (percent)	27.07	6.12	62.5

Even though Pu-239 is more abundant on a weight basis, Pu-241 has a much higher specific activity. The approximate 2:1 (62.5/27.07) activity ratio of Pu-241 /Pu-239 is not consistent with the ratio measured in this borehole (13,00,000/16,000,000).

Although Pu-240 was not detected with the SGLS due to a lack of emission of relatively high yielding gamma rays, it almost certainly exists in this waste stream.

Np-237 is detected with the SGLS by measuring a daughter product protactinium-233 (Pa-233) that emits a prominent gamma ray at an energy of 312.17 keV. Pa-233 was detected from 19 to 24.5 ft. The maximum concentration is approximately 180 pCi/g at a 20.5 ft depth.

A slightly elevated Th-232 concentration as determined using the 2615 keV (T1-208) energy peak is indicated between 19 and 23.5 ft. Both U-232 and Th-232 decay to Th-228, the first decay product of U-232 and the third decay product of Th-232. Therefore, the concentration determined for each decay product from Th-228 to T1-208 will reflect decay from both parents. In spectral gamma log analysis; the 2615 keV T1-208 gamma ray is used to represent the concentration of the naturally occurring parent Th-232. This gamma ray is energetic relative to gammas emitted by the other daughter products and its yield of approximately 35% results in easy detection. However, because the decay chain of naturally occurring Th-232 is modified by the emergence of the decay products of U-232, the natural component of Th-232 must be determined from its second decay product (Ac-228). Ac-228 can be directly measured using the 911 keV gamma ray. The plot of natural gamma logs shows the disruption of the equilibrium (i.e., separation of the 911 and 2615 keV assays) of the natural Th-232 decay, where between 19 and 23.5 ft the Ac-228 indicates Th-232 concentrations below that calculated from the 2615 keV gamma line.

To determine the concentration of U-232, the activity due to natural decay of Th-232, must be subtracted. The Ac-228 concentration is subtracted from the Th-232 concentration calculated based on the 2615 keV T1-208 energy peak. The result is a maximum concentration of approximately 2 pCi/g U-232.

The presence of U-232 suggests that U-233 is also present. U-232 is most likely produced as an impurity in Th-232 target material irradiated with neutrons to produce U-233. In the thorium target material, U-233 will be generated at roughly three orders of magnitude greater than U-232. However, U-233 does not emit detectable gamma rays and gamma emitting decay products generally have not had sufficient time to build in to detectable levels. It is inferred on the basis of the U-232 concentration that approximately 100 to 1000 pCi/g U-233 may exist in this waste stream.

Passive neutron logging was performed in the borehole. This logging method has been shown to be effective in qualitatively detecting zones of alpha-emitting contaminants from secondary neutron flux generated by the (α, n) reaction and may indicate the presence of α-emitting nuclides, including transuranic radionuclides, even where no gamma emissions are available for detection above the MDL. The passive neutron signal depends on the concentration of α sources, and the concentrations of lighter elements such as N, O, F, Mg, Al, and Si, which emit neutrons after alpha capture. The passive neutron log indicated a maximum count rate of 2000 counts per second at 20.5 ft.

A reaction F-19 (α, n) Na-22 yields a gamma ray at 1274.53 keV and a positron at 511 keV. A 1274.44 keV gamma ray also occurs from the decay of Eu-154. However, there are no corroborating peaks for the Eu-154 and the gamma ray is attributed to the fluorine reaction. The half-life of Na-22 is short (i.e., 2.6 years), but will continue to be produced as long as sufficient fluorine and neutron activity exist. The Na-22 was detected from 18.5 to 22.5 ft at similar depth intervals as the relatively high neutron flux detected by the passive neutron logging system. The maximum concentration of Na-22 is approximately 45 pCi/g at 20.5 ft. The 1274 keV energy peak may also be influenced by a prompt gamma ray induced by alpha particles interacting with F-19. Other energy peaks observed in the spectra that could be attributed to reactions with F-19 include ones at approximately 196, 583, 890, and 1236 keV. The existence of these gamma rays strongly suggests that at least some of the identified alpha emitting radionuclides are present as a fluoride.

The PVC sleeve placed over the sonde resulted in Cl-35 neutron capture gamma rays. Gamma ray lines at approximately1165, 1951, 1959, and 786/788 keV were observed in the spectrum at 20.5 ft. The identification of Cl lines in a borehole using this method may be useful in other boreholes where very high gamma activity may affect the passive neutron count rate. It provides a qualitative indication that a high neutron flux exists, even in the presence of high gamma activity.

Other energy peaks are observed in the high neutron flux intervals that represent capture gamma rays from elements in the formation, steel casing, or the waste stream itself. Gamma rays detected and possible sources include a 2223.2-keV H capture λ-ray, Al-28 (n, g) or Mg-25 (α, n) at 1779 keV, Mn-56 at 846.75 keV and 1810.72 keV.

The SGLS repeat logs all show good repeatability.

List of Log Plots:

Depth Scale: 1” = 20 ft

Man-made Radionuclide
Natural Gamma Logs
Combination Plot
Total Gamma & Dead Time
Repeat Section of Man-made Radionuclides
Repeat Section of Natural Gamma Logs

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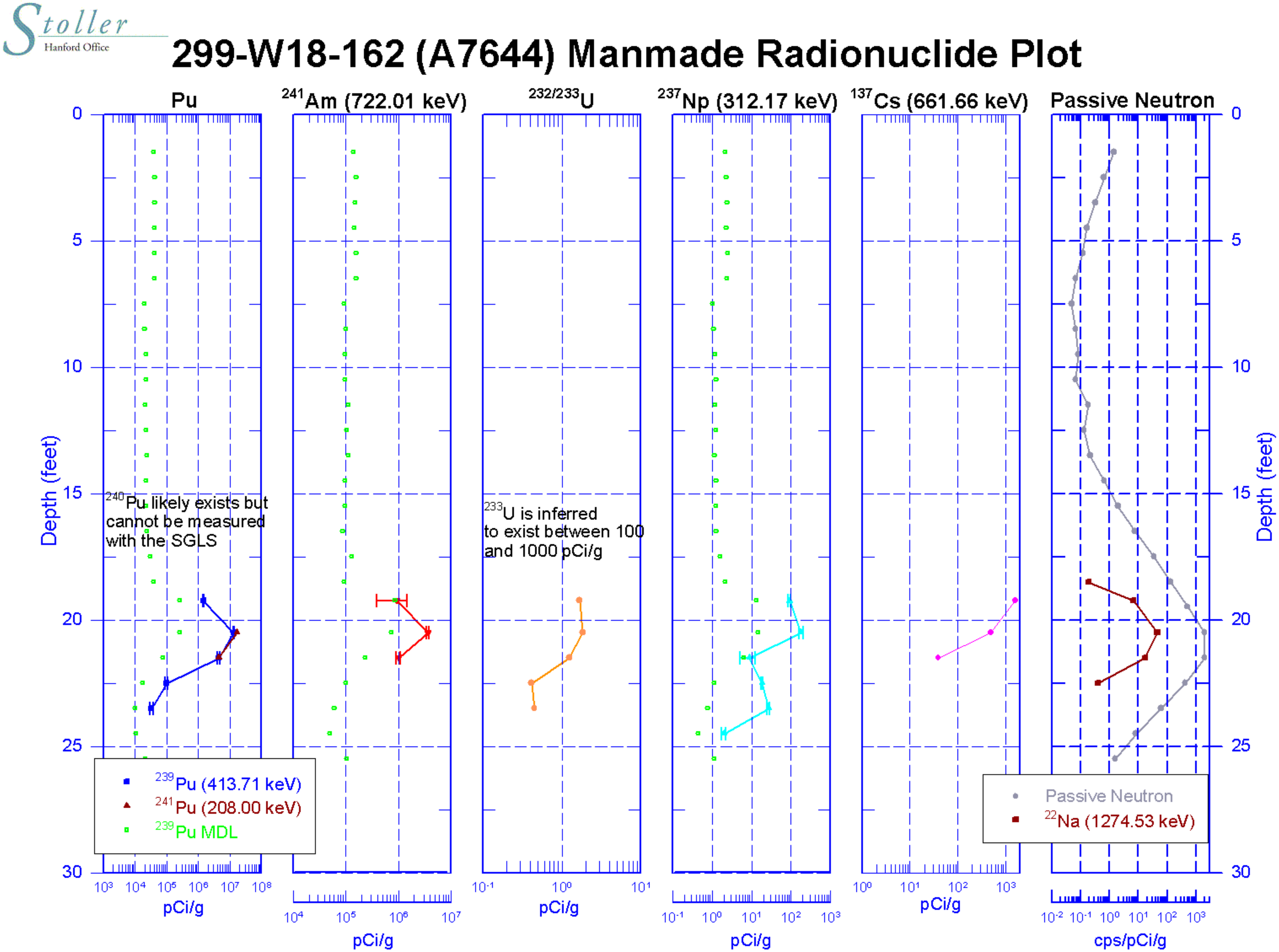
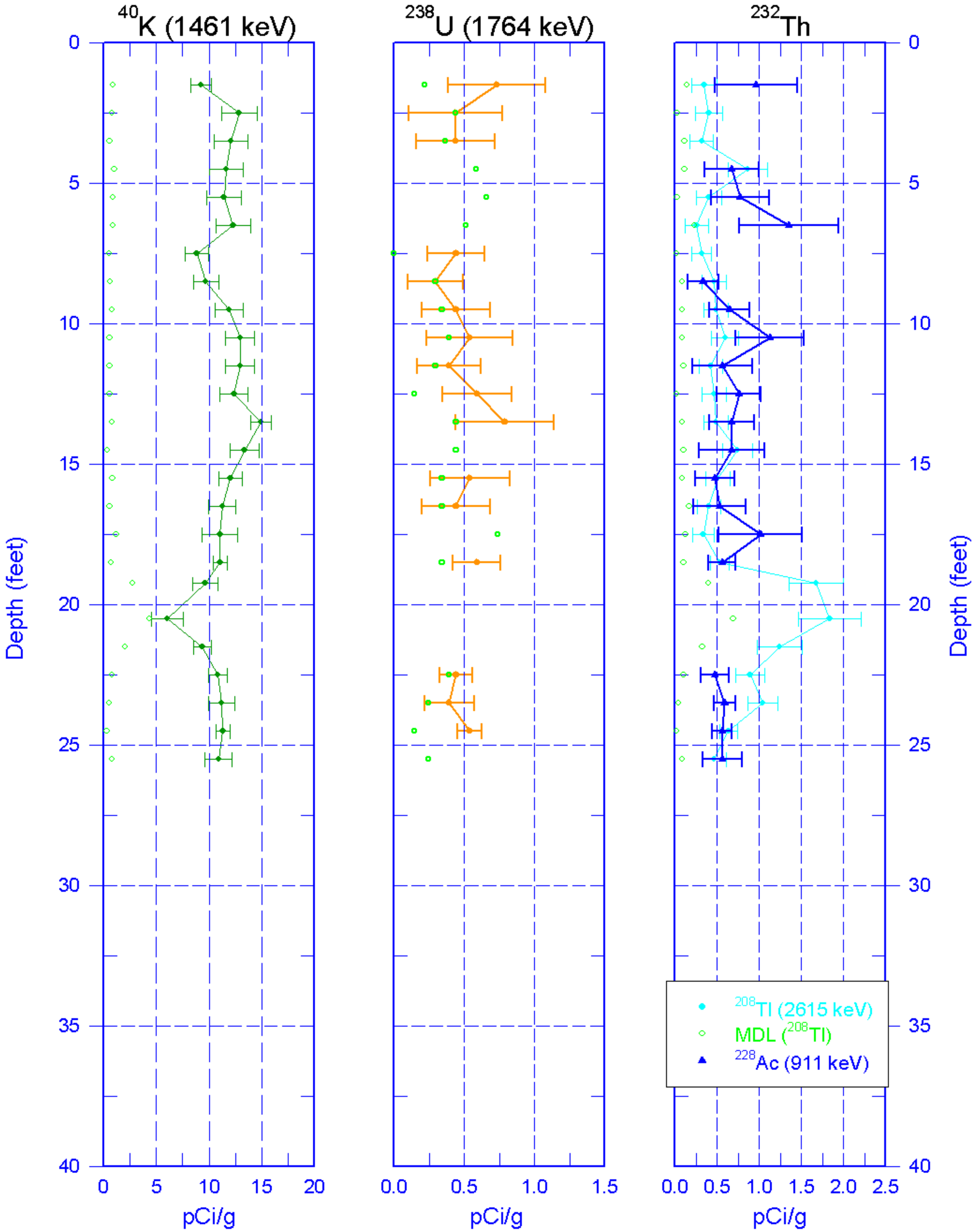
[1] GWL – groundwater level
[2] TOC – top of casing
[3] N/A – not applicable



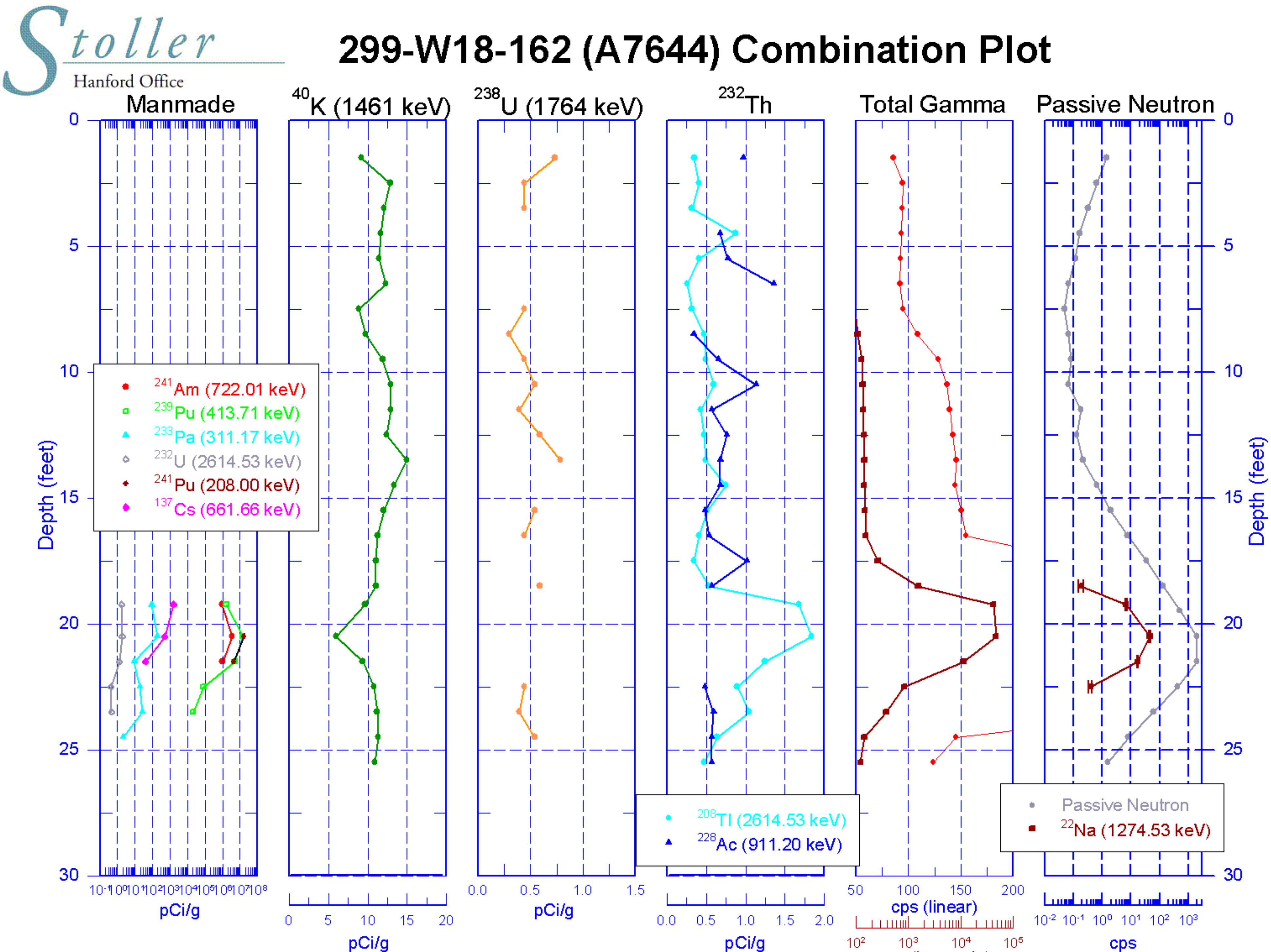
Zero Reference = Top of Casing

299-W18-162 (A7644)
Natural Gamma Logs



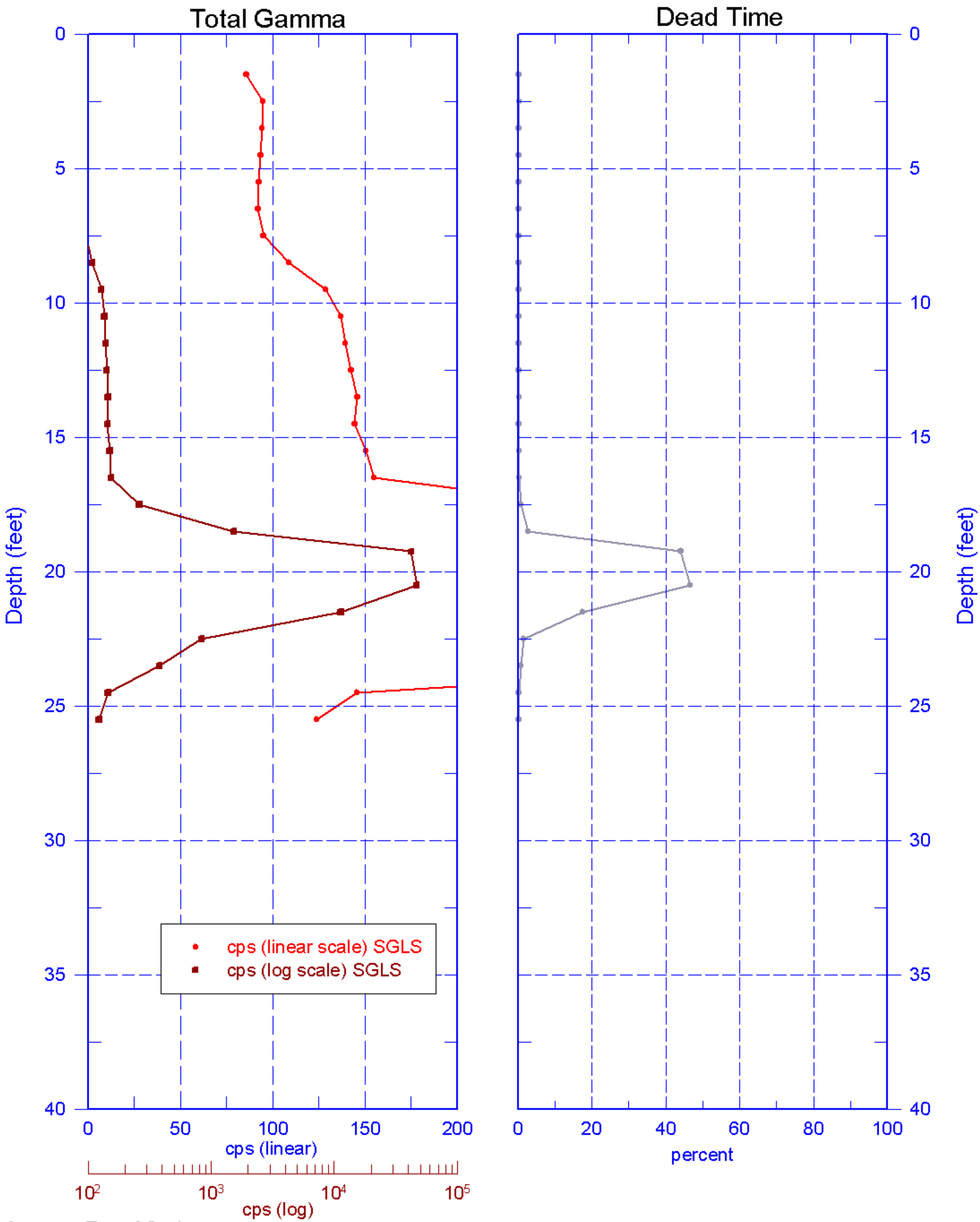
Zero Reference = Top of Casing

299-W18-162 (A7644) Combination Plot



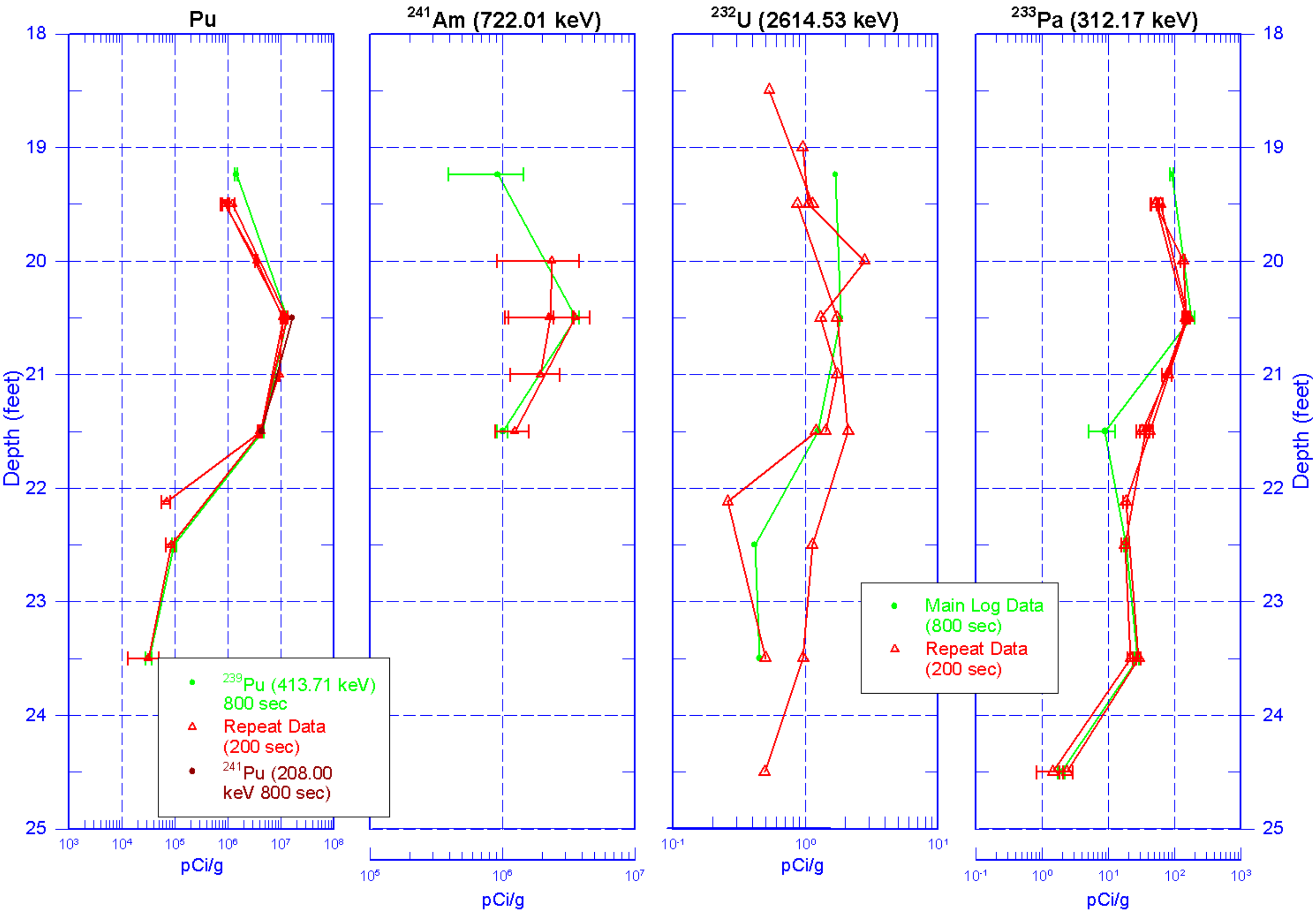
Zero Reference = Top of Casing

299-W18-162 (A7644)
Total Gamma & Dead Time



Reference - Top of Casing

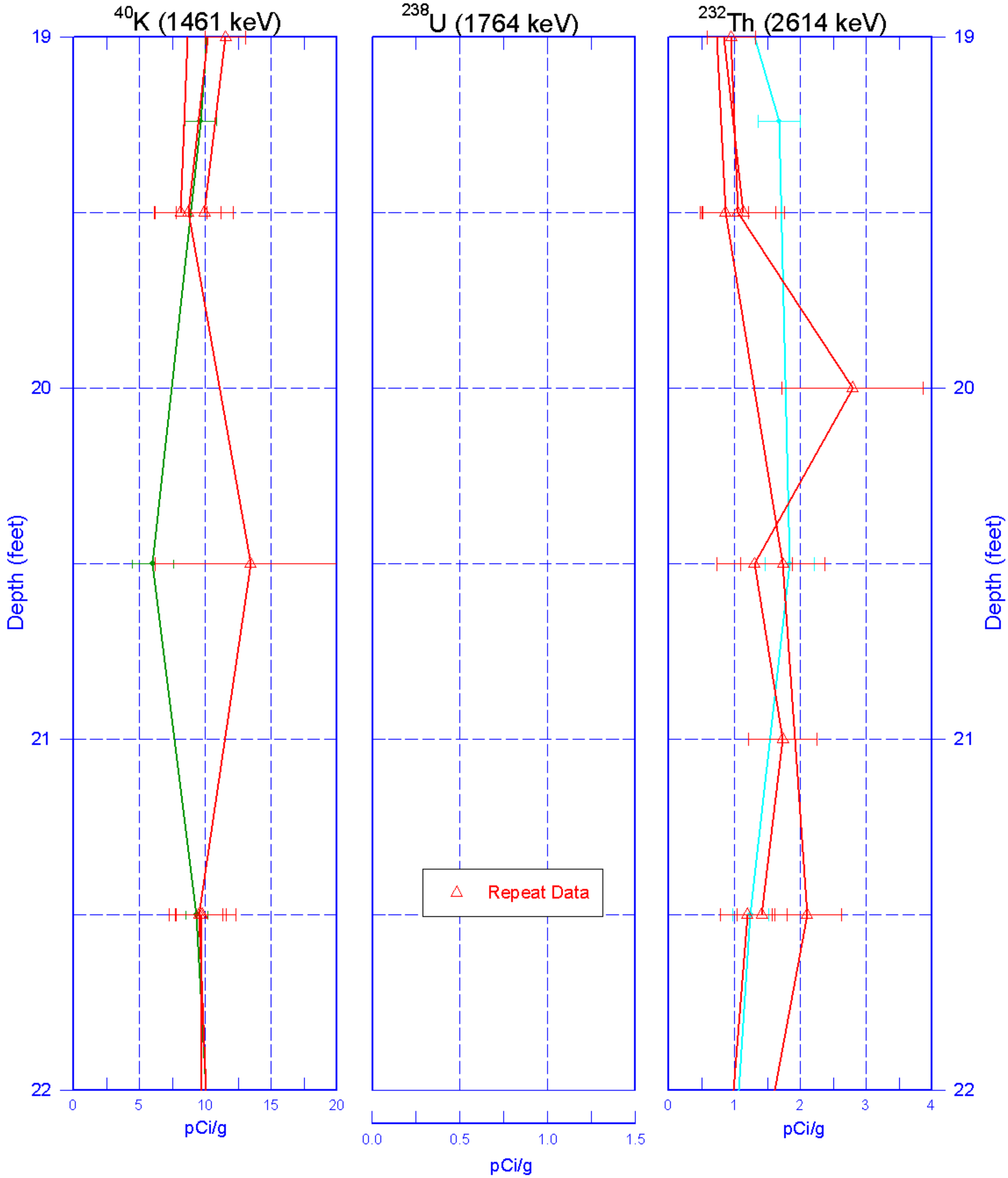
299-W18-162 (A7644) Manmade Radionuclides Repeat Plot



Zero Reference = Top of Casing

299-W18-162 (A7644)

Repeat Section of Natural Gamma Logs



Zero Reference = Top of Casing